ACCELERATION GROUND TEST PROGRAM TO VERIFY GAS PAYLOAD NO. 559 STRUCTURE/SUPPORT AVIONICS AND EXPERIMENT STRUCTURAL INTEGRITY

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ABSTRACT

Acceleration ground tests have been conducted on GAS Payload 559 to verify the structural integrity of the structure/support avionics and two of the planned three flight experiments. The ITA Standardized Experiment Module (ISEM) structure was modified to accommodate the experiments for P/L 559. The ISEM avionics consisted of a heavy duty silver zinc power supply, three orthogonal mounted low range microgravity accelerometers, a tri-axis high range accelerometer, a solid state recorder/programmer sequencer, and pressure and temperature sensors.

The tests were conducted using the Gravitational Plant Physiology Laboratory Centrifuge of the University City Science Center in Philadelphia, PA. The launch-powered flight steady state acceleration profile of the Shuttle was simulated from lift-off through jettison of the External Tank, which occurs at the maximum axial acceleration load in the ascent trajectory of approximately 3.0 g's. Additional tests were conducted at twice (2X) the nominal Shuttle predicted powered flight acceleration levels (6 g's) and an over-test condition of four times (4X) the powered flight loads to 12.6 g's.

The present test program has demonstrated the value of conducting ground tests to verify GAS payload experiment integrity and operation before flying on the Shuttle. This test philosophy will provide the maximum return of zero g data from the GAS program.

1.0 INTRODUCTION

Payload 559 will be flight ready for a Get Away Special Cannister in 1989. The original payload consisted of three basic experiments: the prime experiment (No. 1), Mr. Ivan Vera's Membrane Casting Apparatus, two protein crystal devices experiment (No. 2) sponsored by the Bioprocessing and Pharmaceutical Research Center (BPRC) in Philadelphia, PA, and a protozoa growth experiment (No. 3) sponsored by the Hispanic Community. Acceleration ground tests using a centrifuge were conducted on the ITA Standardized Experiment Module (ISEM) which consists of an aluminum aerospace structure and support avionics (power supply, recorder/sequencer, low and high range accelerometers and pressure and temperature sensors) as shown in Figure 1. Experiments 2 and 3 were mounted to the ISEM during the ground tests, however, Experiment No. 1 was not

available and consequently a mass simulator was utilized to ballast the payload to 200 lbs. P/L 559 will be reconfigured from the above test configuration due to Experiments 2 and 3 being dropped by their sponsors.

2. ISEM AVIONICS

The following support avionics described below were integrated into the basic ISEM structure for the acceleration test program.

- 3 Schaevitz low range ±0.25 g accelerometers
- 1 high range ±20 g three axis Entran accelerometer
- 1 0-20 psia Kulite pressure transducer
- 1 Tattletale recorder/data logger
- 1 Onset computer/recorder/data logger/sequencer
- 6 Yardney silver zinc LR90 cells
- One stainless steel battery box

In addition, signal conditioners and junction boxes were fabricated and mechanically integrated to the structure. The purpose of the signal conditioner/junction boxes is to provide commands, distribute power, and record data.

3.0 TEST PROGRAM DESCRIPTION

The test program was designed to simulate the Shuttle launch/powered flight steady state acceleration profile. The launch profile was simulated out to approximately 530 seconds which corresponds with the separation of the External Tank and an axial load of approximately three (3) g's. The Shuttle acceleration levels are less from this point on in the trajectory to orbit. The ISEM was mounted to the centrifuge using the standard GAS interface. The unit was repositioned on several runs such that the loads could be applied to three orthogonal axes. Functional tests were performed on each experiment and each subsystem of the avionics after each centrifuge run.

4.0 FACILITY DESCRIPTION/TEST SET UP

The University of Pennsylvania Gravitational Plant Physiology Lab centrifuge is a dedicated acceleration research facility that was used for the program. Figure 2 presents a photograph of the centrifuge showing the ISEM mounted inside the test gondola. It should be noted that the ISEM was mechanically mounted to an adaptor plate on the gondola identically to the attachment scheme defined by NASA for Shuttle operations, i.e., a 19 inch bolt hole circle. The centrifuge contained accelerometers mounted adjacent to the top and the bottom of the ISEM.

A control room was located adjacent to the centrifuge room where TV monitors and VCR recorders were used to observe and record the module during the run. In addition, the instantaneous

acceleration levels were recorded for "real time" assessment of the test results and the final data analysis.

5.0 TYPICAL RUN SEQUENCE/TEST PROCEDURE

Pre-test photographs were taken of the payload prior to each run. Functional tests were then conducted on the avionics and the experiments. Voltages of each sensor were monitored and recorded. Pressure and low range accelerometers were stimulated and the responses recorded. The experiments were energized and the motors run in each direction.

The recorder-data logger was then activated and the centrifuge started. The ISEM module was observed by the TV camera mounted on the hub of the centrifuge, and the instantaneous real-time read out of the centrifuge accelerometer levels were monitored and recorded.

After the centrifuge was shut down and ceased to rotate, the onboard recorder was de-activated and the ISEM visually inspected. Post test photographs were taken to document structural integrity of the module and components. Functional tests were then conducted again on each avionics component, and on the experiments to verify that they operated properly after being subjected to the acceleration environment.

The module was then taken out of the cradle to change the orientation for the next run as shown in Figure 3 and the entire procedure was repeated.

6.0 TEST RESULTS

Figure 4 presents the results from the first test which was a standard Shuttle (3 g) run. The difference in readings between centrifuge accelerometers 1 and 2 was due to location differences on the arm. The ISEM accelerometer shows good agreement with the centrifuge data after being biased to one g. Figure 5 presents data for the ramp function to 12.6 g's (4x Shuttle loads). It should be noted that the ISEM flight accelerometer (Entran tri-axis) tended to drift during the entire test series.

A comparison of the Shuttle acceleration profile from flight data with two centrifuge runs (1X and 2X Shuttle) using the ISEM data is shown in Figure 6. This comparison demonstrates that centrifuge facility provides a good simulation of the Shuttle acceleration flight loads.

All of the avionics performed well during this test program with the exception of the three axis Entran accelerometer which tended to drift. As a result of this test program, the Entran acceleromoter is being replaced on Payload 559.

The BPRC crystal growth experiment showed a potential failure mode which has been corrected for the actual flight. Finally, the power supply provided ample power for the test program, however, the Yardney cells "leaked" when subjected to the 12.6 g acceleration ramp function. This points out that orientation of these cells is important when designing a GAS payload.

7. CONCLUSIONS

The following conclusions were reached as a result of this test series:

A. The centrifuge facility provided a good simulation of the steady state acceleration load profile during the launch ascent portion of the Shuttle trajectory.

B. The ISEM structure, avionics, and MPS experiments survived the max loading condition, (12.4 g's) and all electronics and mechanical components successfully operated and passed functional tests after the environments.

C. The three axis high range accelerometer to monitor launch and re-entry loads was found to drift to an unacceptable level during the test program. Accordingly, the accelerometer will be replaced prior to shipment of the payload.

D. A potential failure mode of one of the MPS experiments (protein crystal growth) was identified and subsequent modifications made to the hardware to eliminate the potential failure mode.

8. CONCLUDING REMARKS

The present test program has demonstrated the value of conducting ground tests to verify GAS payload experiment integrity and operation before flying on the Shuttle. This test philosophy will provide the maximum return of zero g data from the GAS program. Subsequent additional tests are planned for Payload 559 after reconfiguring some of the experiments. The reconfigured payload will be subjected to the Shuttle vibration environment prior to shipment to NASA.

9. ACKNOWLEDGEMENTS

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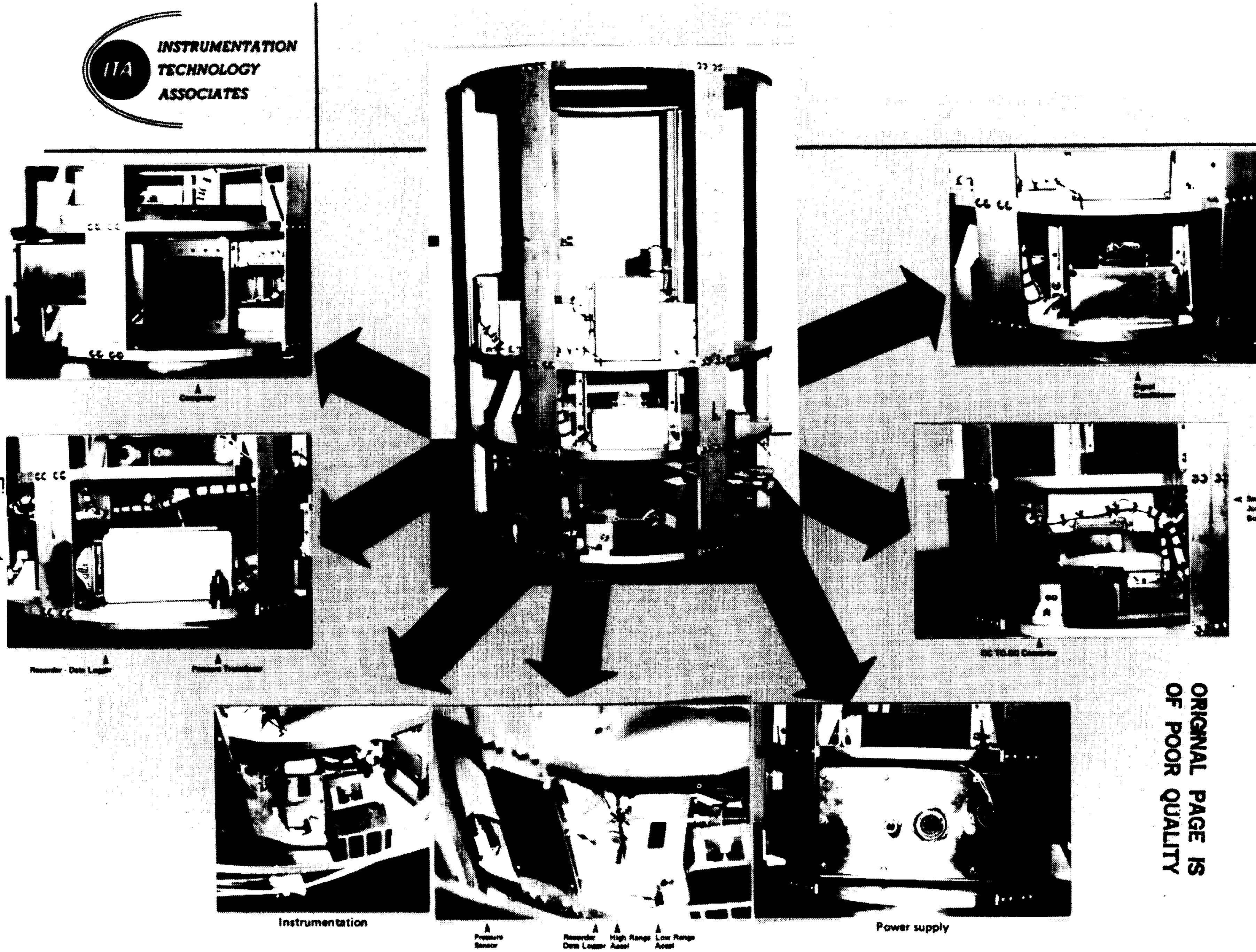

Figure 1

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Figure 2 Centrifuge with Test Gondola

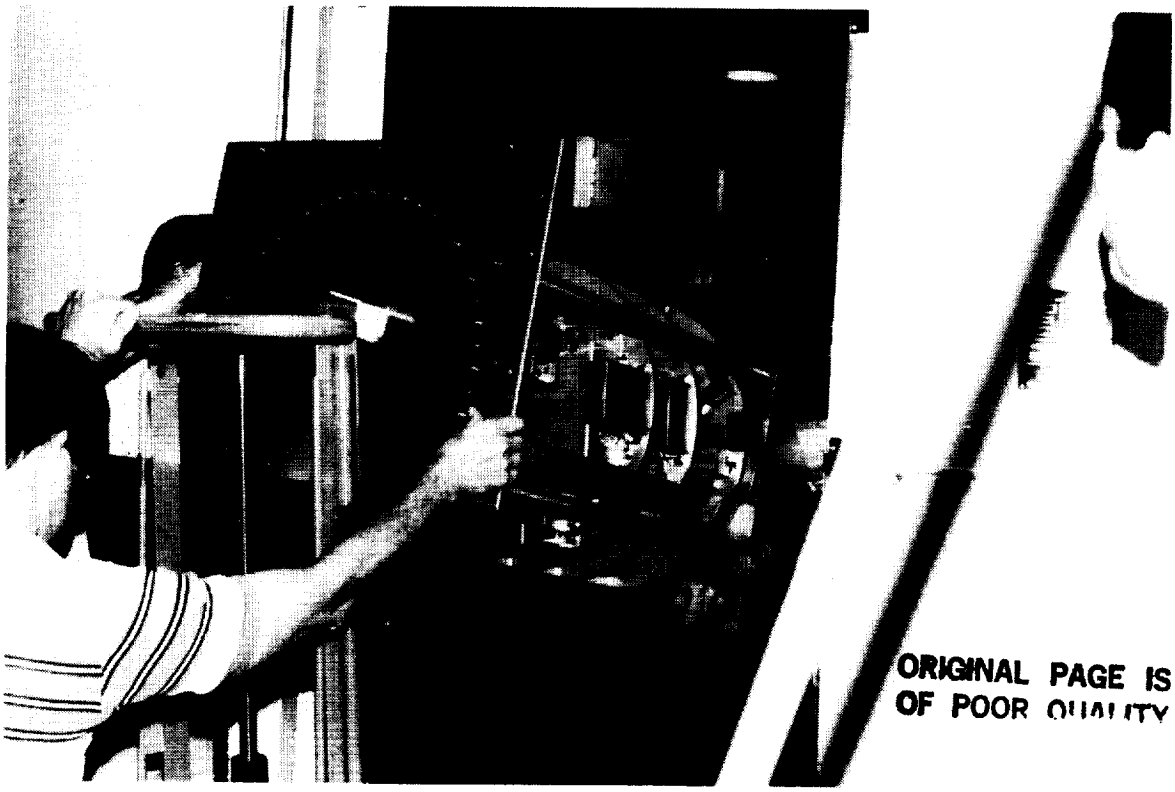

Figure 3 ISEM Being Repositioned to Change Load Vector

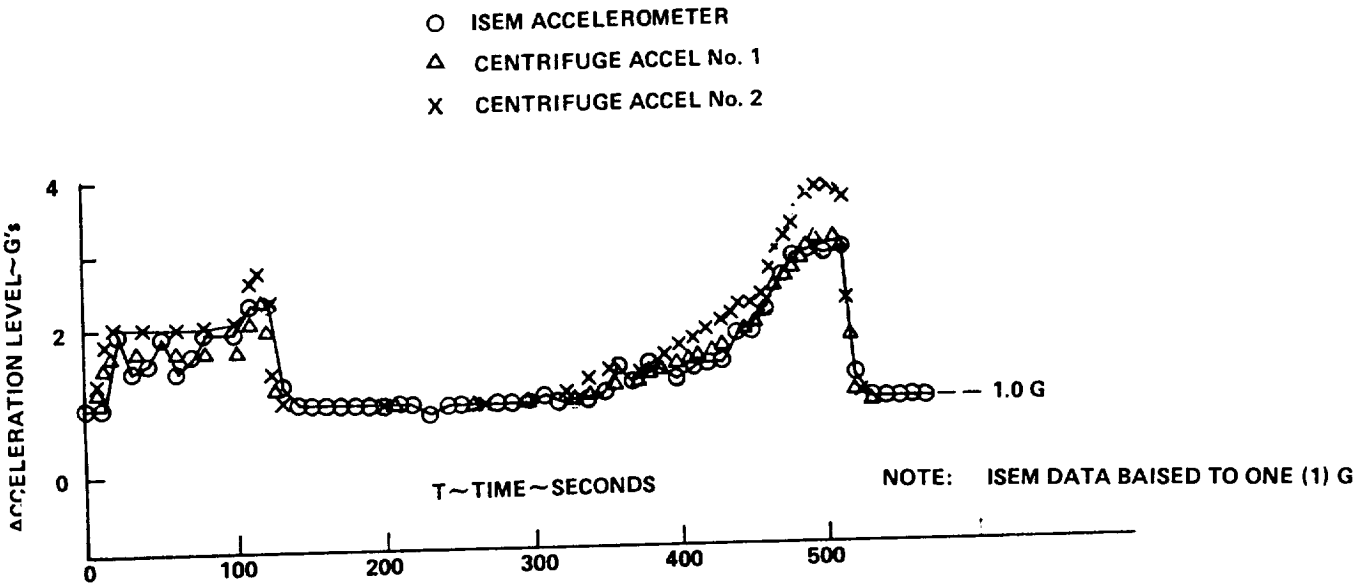

Figure 4. Centrifuge Test Data for Normal Shuttle Loads

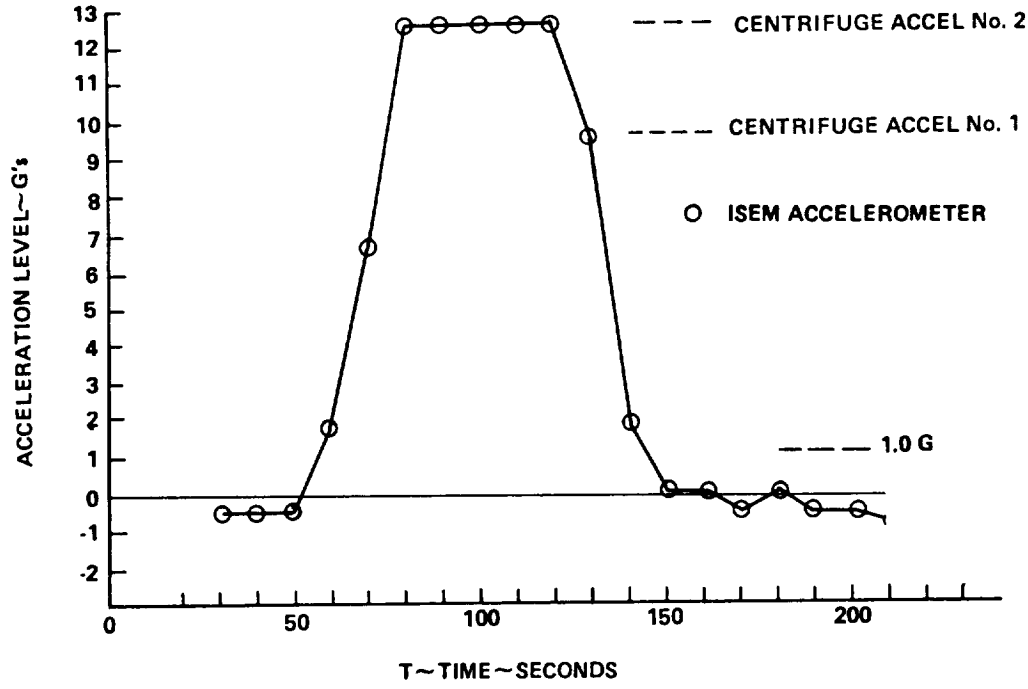

Figure 5. Centrifuge Test Data for 4X Shuttle Loads

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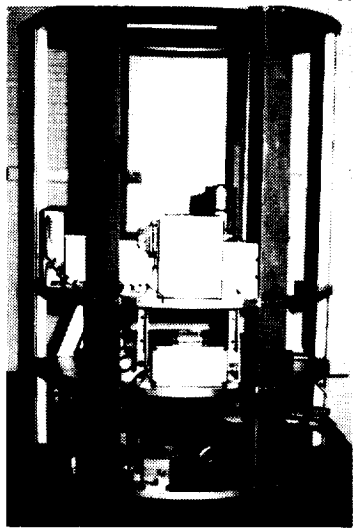
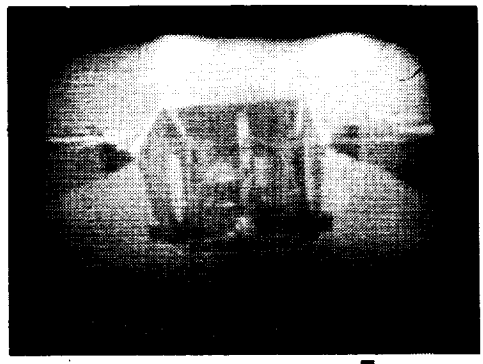
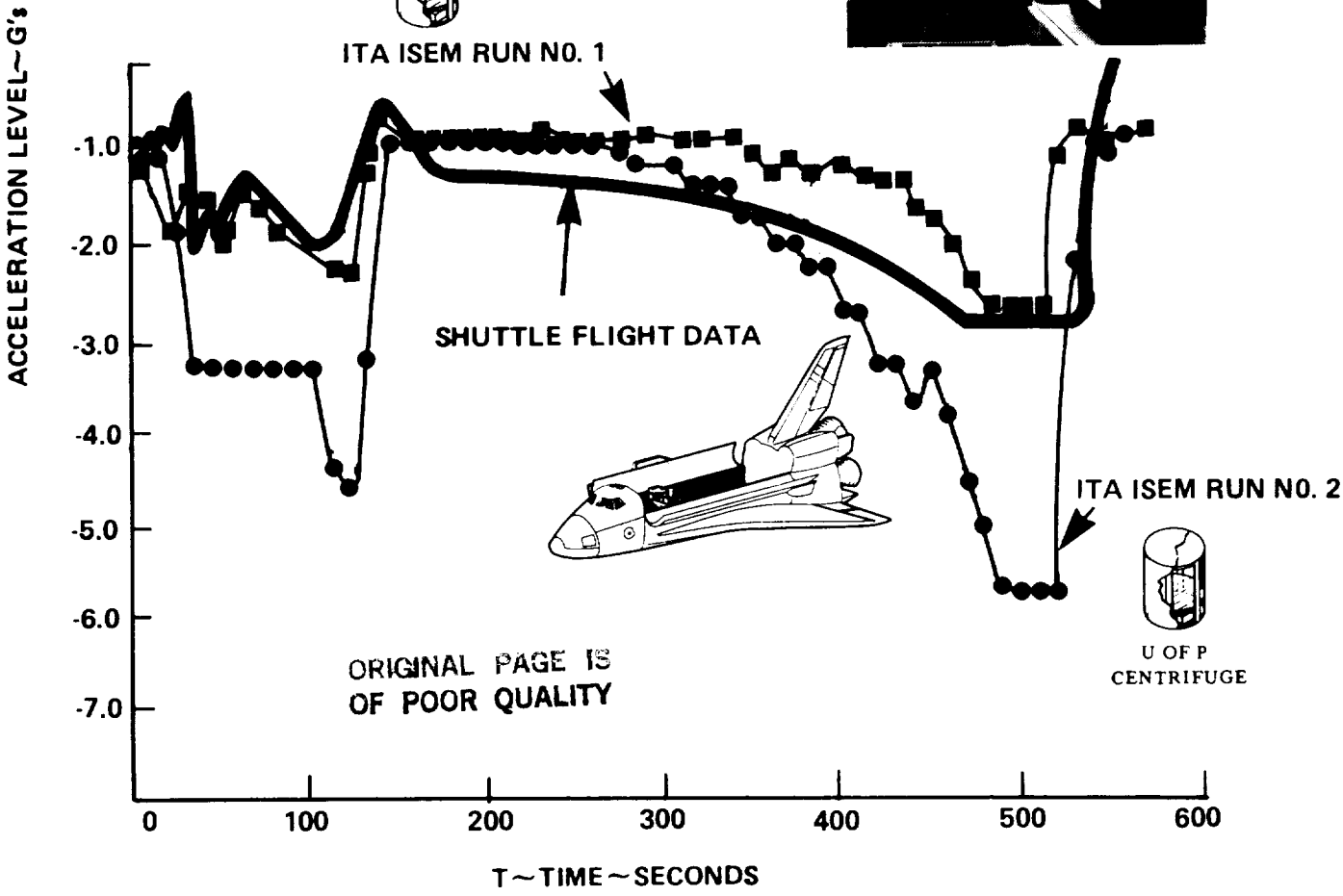
COMPARISON OF U OF P CENTRIFUGE GROUND TEST DATA WITH SHUTTLE FLIGHT DATA FOR LAUNCH ASCENT ACCELERATION PROFILE

U OF P CENTRIFUGE







DATA SOURCE: ITA CENTRIFUGE TESTS, JULY 1986

Figure 6